Proposal of Automatic Dust Catcher Robot of Clothes Using Kinect

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Abstract

If you come into contact with others with dust or animal hair on your clothes, there is a high possibility that you will make the other person develop an allergy or not be able to establish good communication. Thus, it is necessary to remove dusts and more from your clothes before going out. However, this work is done manually, which is time-consuming and time-consuming. To solve this problem, last time we developed a robot that automatically removes dust from clothes on hangers with a brush. The robot holds and pinches the clothes between two brushes and removes the dust by moving the brushes from top to bottom. It also removes dust from the entire clothes by repeatedly extending the arm with the brush attached and removing the dust. However, this robot could only operate for one garment at a time. In this paper, we develop a robot that can continuously care for multiple clothes. First, this robot rotates the hanger rack. Next, use the Kinect camera to look at the front of the brush and stop the rotation of the hanger rack when the clothes come. Third, remove the dust from the clothes in the same way as the previous robot we created. By repeating the above operation, multiple clothes can be removed dust in succession. The operation time of this robot is about two minutes. All the user has to do is put the clothes on the hanger, press the start button on the robot, and the robot will remove the dust from the clothes. While the robot is running, the user can spend his time doing other things. For example, by using this robot, you can make better use of your valuable morning time for yourself instead of using it to dust your clothes.

Keywords: clothes, dust, brush.

1. Introduction

House dust, mites, and animals can cause allergies⁽¹⁾⁻⁽⁴⁾. It is dangerous to come in contact with allergy sufferers with

these substances on your clothes⁽⁵⁾⁻⁽⁷⁾. Therefore, it is necessary to remove dust and other particles from clothes when there is a possibility of contacting with people.

Also, appearance is a quite important point in giving a positive impression on others⁽⁸⁾. According to the questionnaire on marriage activities conducted in 2020 by Partner Agent, a dating agency operated by Tameny Corporation says 48.4% of men and 65.0% women of 978 men and women aged 30-39 who have done marriage activities ranked appearance and cleanliness as the most important factor in determining the impression of a partner or the factor that makes a good impression in marriage activities⁽⁹⁾. This is the most common answer for both men and women. In addition, according to the questionnaire conducted in 2019 by this corporation shows, 54.7% of 320 men and women aged 20-39 answered that cleanliness is an important factor in what they look for in a marriage partner⁽¹⁰⁾.

Thus, wearing clean clothes is one of the things we need to do to maintain good health for ourselves and others, and to build good relationships with others. In order to wear clean clothes, it is necessary to wash, iron out wrinkles, and remove dust from clothes. In this paper, we focused on the task of removing dust from clothes.

Since the average member of household in Japan is two people, we consider the amount of dust generated at this time⁽¹¹⁾. According to "On the generation of dust in rooms", a collection of reports by the Architectural Institute of Japan in 1966, the dust generation rate when two people are in one room is $2.44 \times 10^{-3} (\text{m}^3/\text{s})$ ⁽¹²⁾.

Many people have pets. According to the national survey of the Pet Food Association's in 2020, 6.8 million households have 8.49 million dogs and 5.51 million households have 9.64 million cats⁽¹³⁾. Dogs and cats shed a

Fig. 1. Robot.

lot of hair. One Labrador retriever sheds 238 hairs per 30 minutes, which is 11424 hairs a day⁽¹⁴⁾. Many pet owners are troubled by their pets' hair loss⁽¹⁵⁾⁽¹⁶⁾ Kärcher Japan Co. surveyed 500 men and women who own a dog or cat in 2019⁽¹⁷⁾. According to it, the biggest concern for the majority of them when cleaning was dirt around the floor caused by pet hair. Animal hair, which falls on the floor in large quantities, adheres to our clothes as we sit or walk. In this way, if you keep animals such as dogs and cats indoors, a lot of animal hair will stick to your clothes in addition to dust.

Dust and animal hair on clothes are mostly removed by using rolls of adhesive tape, special brushes, and other useful items. However, these need to be done manually, which can be a big burden if you have a lot of clothes or if you have a dog or cat.

Many people spend a lot of time grooming themselves in the morning before going to work⁽¹⁸⁾. And many people feel that they don't have time in the morning. According to the survey on how people spend their mornings on workdays conducted in 2012 by Lion Corporation shows, 65.1% of 1000 office worker aged 20-50 answered that don't have enough time on the morning of the day that have to go to work⁽¹⁹⁾. In addition, in this survey, when asked how much they could afford to pay for a minute of their busy morning, the average answer was 531 yen.

In the past, we have developed robots that control brushes to remove dust from clothes⁽²⁰⁾. However, this robot could only dust one piece of garment at a time. In this paper, we propose a robot that can operate continuously on multiple clothes by combining a robot developed in the past with a rotating hanger rack⁽²¹⁾. This robot first rotates the hanger rack when the start button is pressed. Next, using the Kinect camera, when a garment comes in front of the brush, it stops

(a) Drive unit 1.

(b) Drive unit 2.

Fig. 2. Drive units.

rotating the hanger rack and removes the dust from the clothes in the same way as the previous robot we developed. By repeating the above process, multiple clothes can be dusted in succession.

2. Automatic Dust Catcher Robot of Clothes Using Kinect

The overall view of the prototype machine is shown in Figure 1. The rotating hanger rack on the right is where you hang your clothes. The size of the robot's main body on the left is about 740W × 495D × 1360H (mm), and the arm with the brush (Kyowa Kogyo Co., Ltd. MUGENBRUSH) juts out 380~830 (mm). The robot's main body is something we have developed in the past, and it does the job of removing dust from clothes. The robot's main body holds the clothes between two brushes and moves them from top to bottom to remove the dust. The robot then extends the

Fig. 3. Moves up and down.

brushes several times and repeats the above operation to remove dust from the entire clothes. The above motions are controlled as the axes that hold, move up and down, and extend the clothes. However, the main body of the robot alone could only remove dust from one piece of garment at a time. In this paper, we propose a robot that can operate continuously to multiple clothes by combining the robot body with a rotating hanger rack. The robot rotates a hanger rack and uses Kinect (Microsoft, Xbox One) to perform image processing to continuously remove dust from multiple clothes. The hanger rack is rotated by a motor (TAMIYA, 540K300) and controlled by a motor driver (Pololu, MD03A). The mechanism of each axis of the robot body is shown in Sections 2.1~2.3, and the control method of the hanger rack by image processing is shown in Section 2.4.

2.1 Axis to hold clothes

A photo of the pinching axis of the prototype machine is shown in Figure 2. As shown in Fig. 2, only one of the brushes has a drive unit on each side. The two drive units are called the drive unit 1 in Fig. 2(a) and the drive unit 2 in Fig. 2(b), respectively. The two drive units are driven simultaneously to pinch the clothes. The brushes are driven up to 160 mm in the pinching direction. This motion is achieved by winding the wire using a motor (TAMIYA, 4-Speed Worm Gearbox H.E.) and pulleys. The motor is run using a 5(V) DC power supply, and the drive direction is controlled using a motor driver (Toshiba, TA7291P). In addition, a distance sensor (Sharp, GP2Y0E03) is installed in each of the two driving sections, and the width of the sandwich is controlled using an Arduino.

Fig. 4. Arms.

Fig. 5. Extend.

2.2 Axis to move the brush up and down

Fig. 3 shows the mechanism for moving the brush up and down in the prototype. The two brushes are moved up and down by simultaneously driving the two mechanism for extending brushes as shown Fig. 3. Fig. 4 shows the top view of the arms with the brushes attached. The arms are called Arm 1 and Arm 2 respectively, as shown in Fig. 4. The brushes are driven up and down the maximum of 520 (mm). The motor (TAMIYA, AO-8037 Geared Motor 540K300) and the wires are used for this movement. The motor runs on a 12(V) DC power supply and winds the wire with a pipe. The motor driver (Pololu, VNH3SP30) is used to control the drive direction. In addition, a distance sensor (Sharp, GP2Y0A02) is installed in each of the two drive sections, and the height at which it is moved can be controlled using an Arduino.

2.3 Axis to extend the brush

Fig. 5 shows the mechanism for extending the brushes of the prototype as in Section 2.2, we distinguish the arms to

Fig. 6. Short pants as seen from Kinect.

Fig. 7. Binarized image with narrowed range.

be driven as in Fig. 9. The brushes are driven the maximum of 450 (mm). This movement is achieved by using a motor (TAMIYA, 4-Speed Worm Gearbox H.E.) and a pulley to wind the wire. The motor is run using a 5(V) DC power supply, and the drive method is controlled using a motor driver (Toshiba, TA7291P). In addition, the axis to be extended can be seen by the distance sensor (Sharp, GP2Y0A21YK0F), and the distance to extend the brush can be controlled using the Arduino.

2.4 Controlling a Hanger Rack by Image Processing

To operate continuously on multiple pieces of garment, image processing is performed using Kinect to control the rotating hanger rack. As shown in Fig. 1, a Kinect is placed on top of the robot body so that the robot can see the clothes hung on the hanger rack. The robot acquires distance images from the Kinect and performs image processing. The hanger rack stops rotating when the image processing confirms that the clothes are in front of the robot body. Next, the robot removes the dust from the clothes. When the robot finishes its work, the hanger rack starts to rotate again. By repeating the above operation, the robot can operate continuously on multiple clothes.

When the clothes are in front of the robot body, the distance from Kinect to the clothes is about 650 (mm). When there is an object between 600~800 (mm) from the Kinect,

we assumed that the clothes are in front of the robot body. First, the distance image acquired from the Kinect was converted into a binarized image as black when there is an object within the above distance range and white when there is not. At this time, a part of the hanger rack will also be within the above distance. Thus, when the clothes were in front of the robot body, we defined the range in which the clothes were definitely and only visible in the image. This range was defined as within 250~300 horizontal and 280~380 vertical pixels of an image of size 512×424 . The presence or absence of clothes was judged according to how much of the black displayed when an object was in 600 ~ 800 (mm) was within that range. In this paper, we consider the blurring of the image caused by the rotation of the hanger rack and the error in the control of the motor. Stop the motor when the black area reaches 50% within the range where the clothes can be seen. Fig. 6 shows the clothes as seen from the Kinect until the hanger rack stops rotating. Fig. 7 shows a binarized image with a narrowed range at the time of Fig. 6. Fig. 6 and 7 are obtained from the Kinect, so the left and right sides are reversed.

The Kinect is operated by a PC, and the motors that operate the robot body and rotate the rotating hanger rack are controlled by an Arduino. First, the Arduino rotates the rotating hanger rack; the PC starts Kinect and sends a signal from the PC to the Arduino when the clothes come to the

front of the robot body using the above identification method. After confirming the reception with the Arduino, the robot stops the rotation of the hanger rack, and then performs the action of removing the dust from the clothes with the robot body. When the robot is finished, it rotates the hanger rack again and sends a signal from the Arduino to the PC. After confirming the reception by the PC, the Kinect will start discriminating again. By repeating the above actions, the robot can operate for multiple clothes. However, the above operation has a problem that the hanger rack keeps rotating forever. To solve this problem, the robot operation was terminated when the hanger rack made one rotation. First, we measured the time it takes for the hanger rack to make one rotation. On the Arduino side, the time while the hanger rack is rotating is measured and compared with the time for one rotation to control it. Since the time required for the hanger rack used in this paper to make one rotation is about 23 seconds, the robot is controlled to end its operation when the rotation exceeded 26 seconds to account for errors.

3. Experiment

In this paper, we control a rotating hanger rack in order to make the robot work continuously on multiple pieces of clothes. A 100% polyester, small and medium size short pants was used as a sample of the clothes. Using Kinect, we verified the operation of the hanger rack using the discrimination method described in section 2.4. By using the above discrimination method, we verified whether the hanger rack could be controlled so that the clothes always stopped in front of the robot's main body.

The hanger rack was controlled using the method described in section 2.4. We hung two pairs of short pants on the hanger rack and moved the robot until the hanger rack made one rotation and automatically finished. As a substitute for the original motion of the robot's main body, we simulated the motion of the entire robot by blinking the LED five times every 0.5 seconds. The hanger rack was rotated 10 times using the method described above, and the x-coordinate of the center of gravity of the short pants in the image was measured and observed to see if it always stopped in front of the robot body. The x-coordinate of the center of gravity of the clothes was measured by performing the binarization process of the distance image described in section 2.4 on the entire distance image acquired, while inverting it in black and white. When the garment was in front of the robot body, the x-coordinate of the center of gravity of the short pants in the image was 300, so this was used

as the reference. The difference between the measured x-coordinate of the center of gravity of the short pants and the reference value is shown in Table 1. Table 1 shows that the error is small, so the clothes always stop in front of the robot's main body.

4. Conclusions

In this paper, we have proposed and simulated a system that can operate on multiple pieces of dusty clothes. We believe that this robot can solve the problem of removing dust of only one single garment at a time, which has been a problem in previous paper. This robot can remove dust from all the clothes hung on the rotating hanger rack. The user only needs to hang the clothes on the hanger rack and collect the clothes after the robot's operation. Therefore, the time spent on removing dust of clothes can be used for other things. For example, the valuable time in the morning can be effectively used for other things instead of removing dust of clothes.

In the future, it is necessary to verify whether the robot can remove dust of multiple pieces of garment by operating the entire system with the robot itself. Another issue is to improve the stability of the axes of the robot body, which has been an issue in previous papers. In addition, it would be more convenient if the robot could perform removing dust of operations for clothes of different materials and sizes.

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